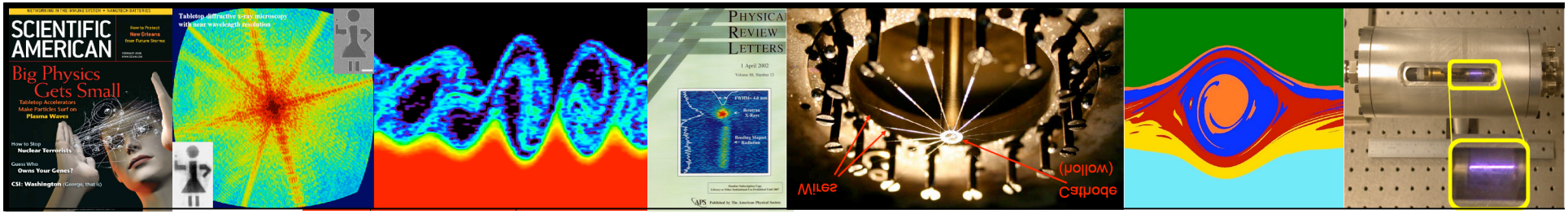
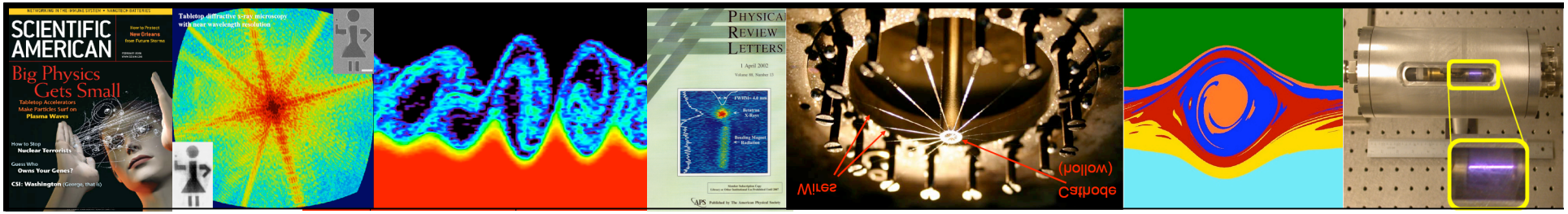


High Energy Density Science Association's (HEDSA) View of HEDLP

- High Energy Density Science is in its discovery phase, enabled by powerful new large, intermediate scale and small machines that are just coming on-line

- We will breach scientific frontiers in energy density to explore, for example - coherent control of plasmas, plasma self-organization, dense, cold, quantum plasmas, materials under extreme conditions, manipulating electron dynamics, exotic astrophysical processes, probing matter on ultrashort space and time scales

- Our community wants to build a vigorous, productive, and cooperative, peer-reviewed HEDLP program through workshops, benefiting from the DOE-BES model. Doubling in number in a year or two is our goal.

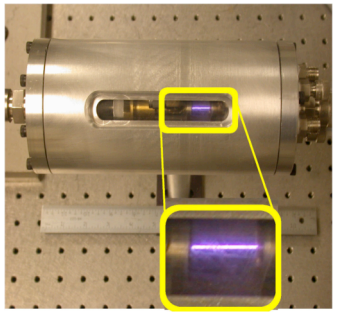


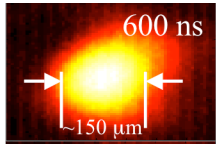
Highlights of Frontier Research in HEDLP

- From Nonlinear Optics (a prominent, recurrent theme) to warm dense matter and new phenomenology
- From pulsed power drive, ultra-high magnetic fields and shock heating to ultrashort pulse intense laser interactions with atoms and electrons
- From massively parallel simulations of highly nonlinear and kinetic plasma phenomena to IFES and Fast Ignition
- From basic physics of collective excitations with no linear and no fluid counterpart, low entropy self organized states of plasmas unique to HEDLP, to novel diagnostics and experimental innovations

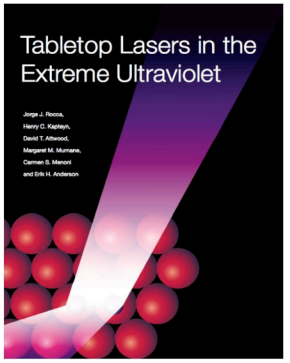
Nonlinear optics in engineered plasmas

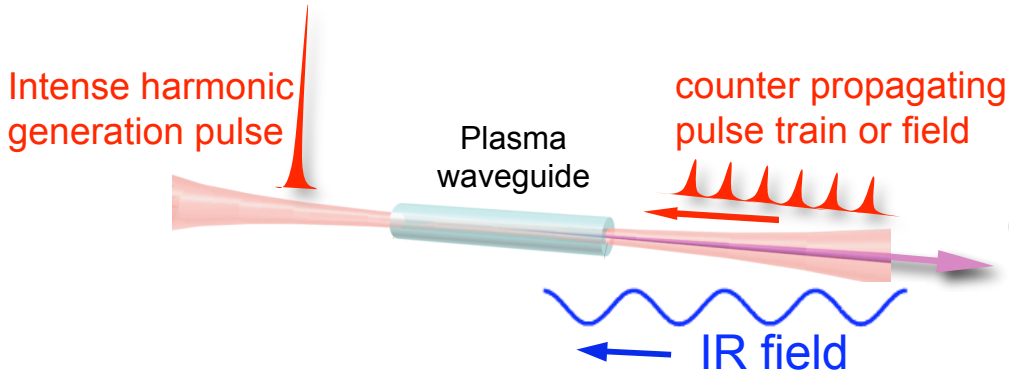
- **Generating bright coherent keV beams using tabletop sources will *require***
  - exploring the limits of quantum phenomena in high energy density environments
  - engineered plasmas to manipulate electrons and to guide intense laser beams
  - new nonlinear-optical schemes using multiply-ionized or structured plasmas
- **Applications in plasma, nano, materials, magnetics, and bio imaging, seeding next-generation FELs**





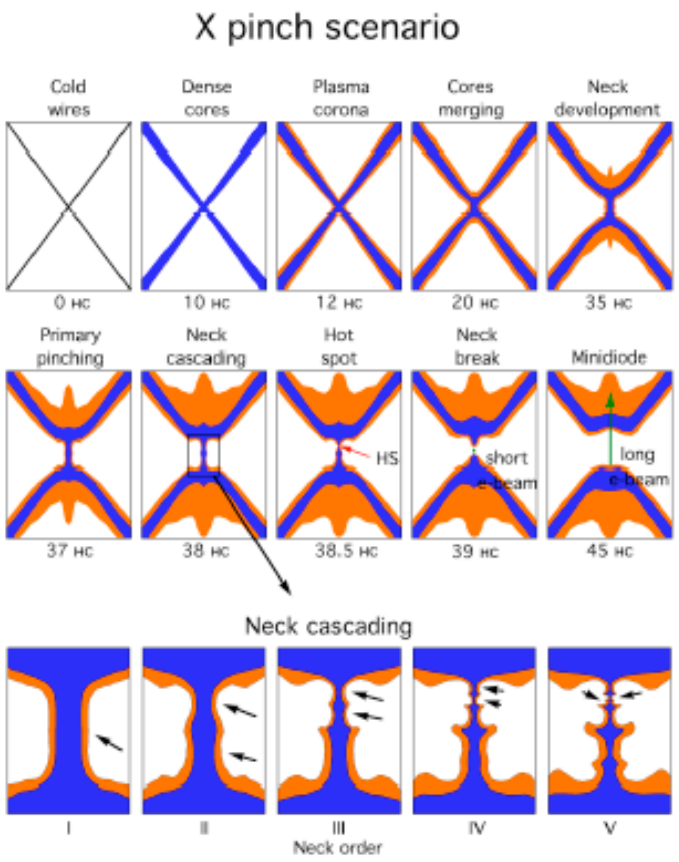
Guided laser beam

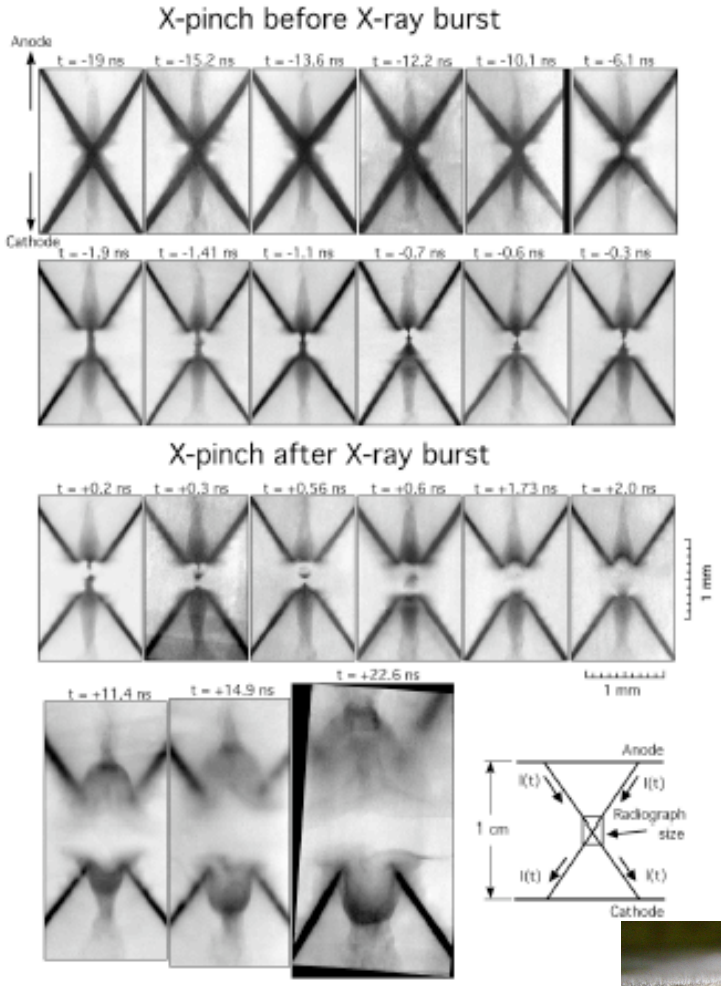


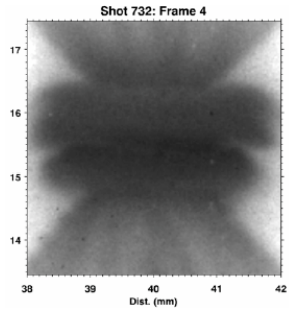


PRL ***96****, 203001 (2006); PRL* ***98****, 043903 (2007); PRL* ***99****, 53902 (2007); Nat. Phys* ***3****, 270 (2007); Science* ***317****, 775 (2007)*

The Evolution of an X Pinch As Imaged By Another X Pinch

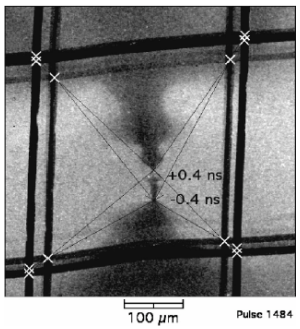






Blast wave

20 μm/ns radial expansion XUV image

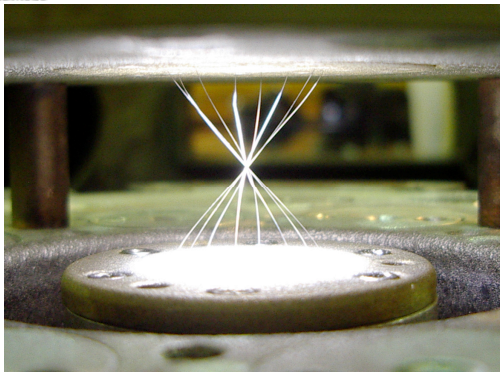


X-ray source location

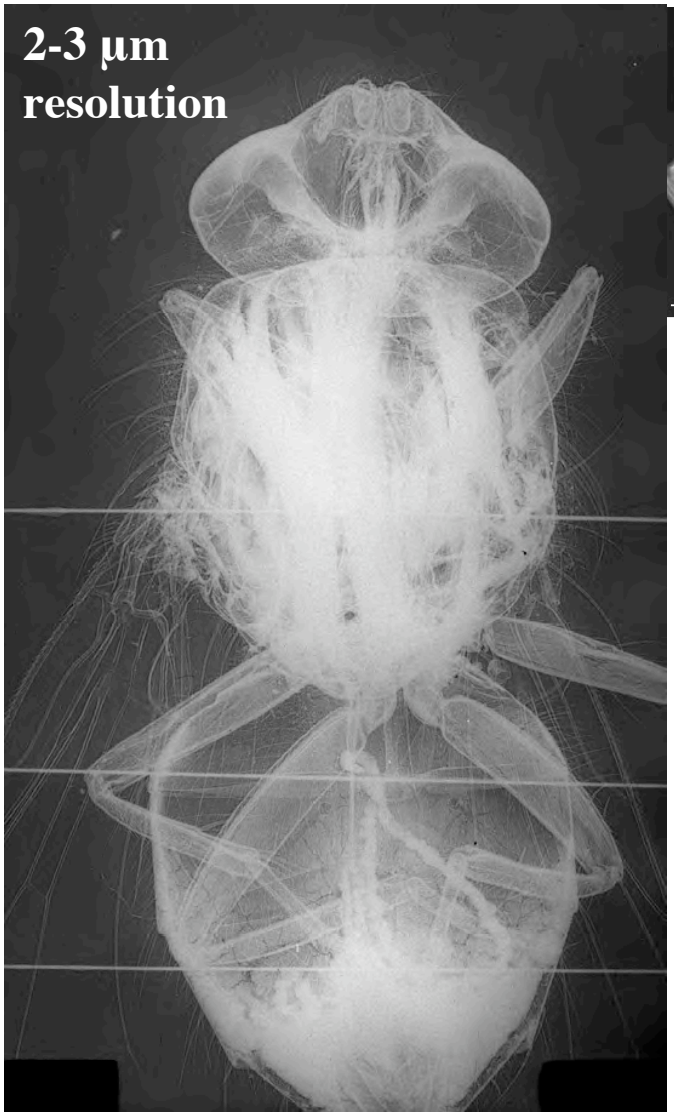
Radiograph

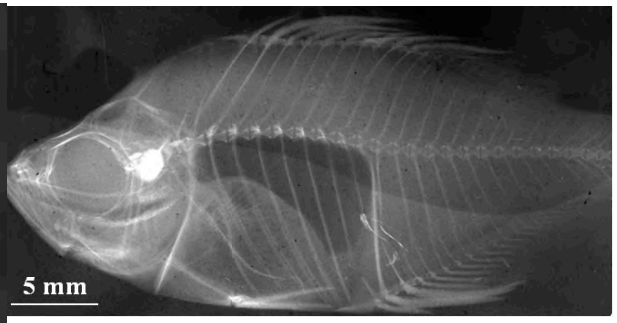
Shock wave in dense plasma

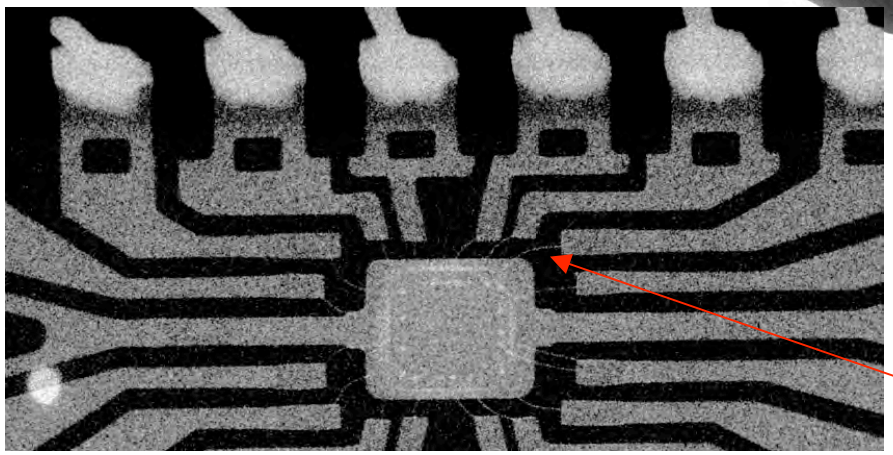
Radiographs



Micron Scale Imaging Made Possible By X Pinch X Ray Sources

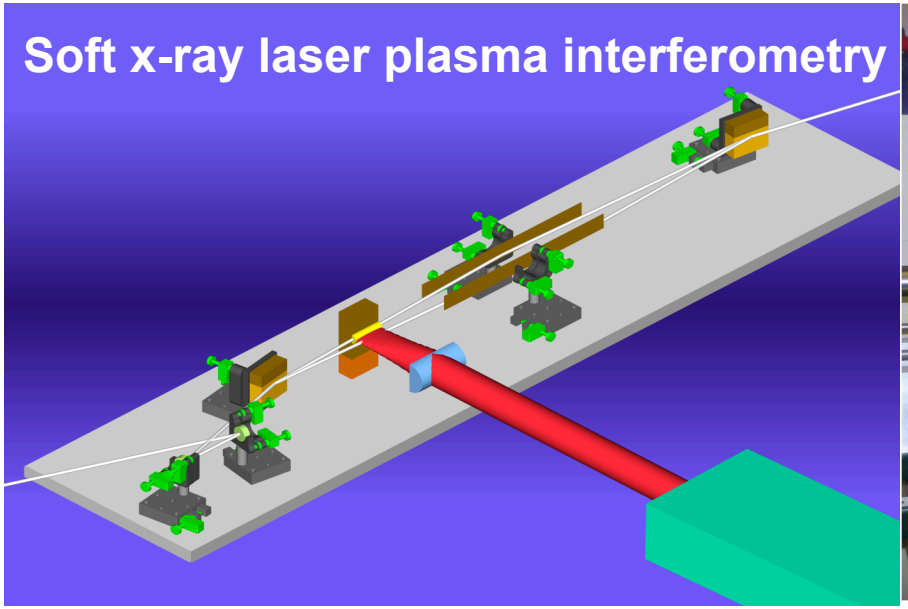


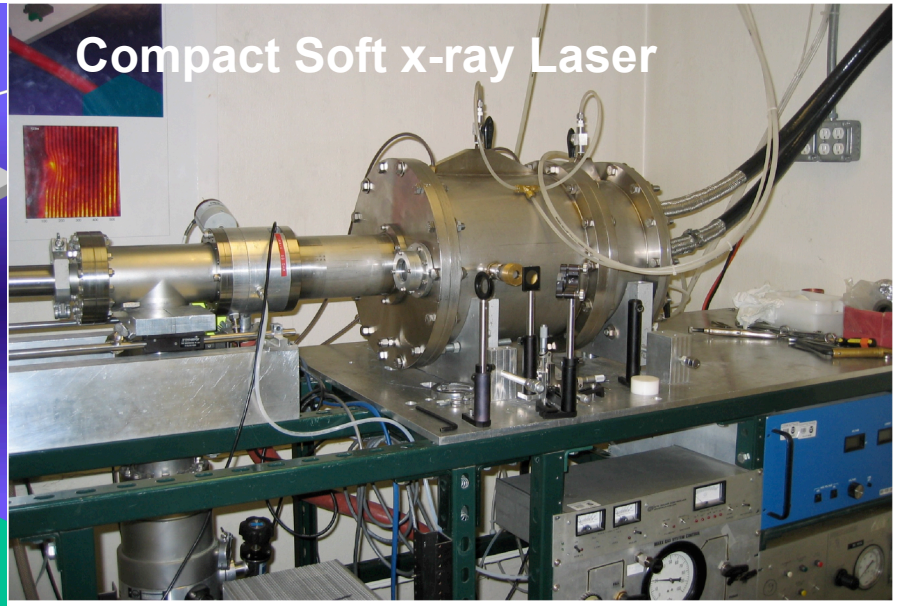


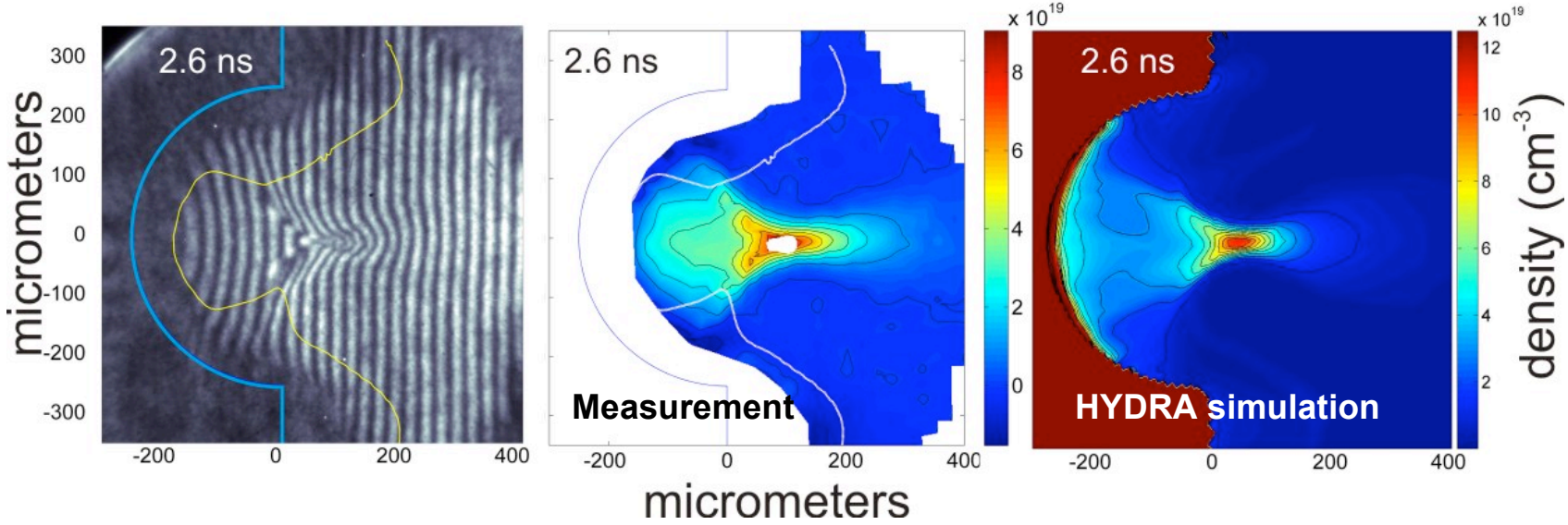


40 µm
connector

Soft x-ray laser interferometry greatly expands the range of plasma density accessible to laser probes



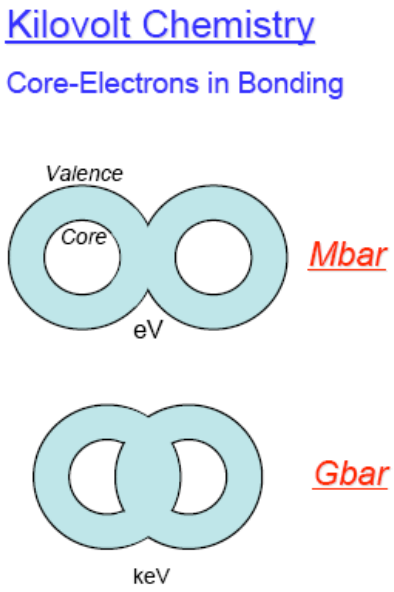


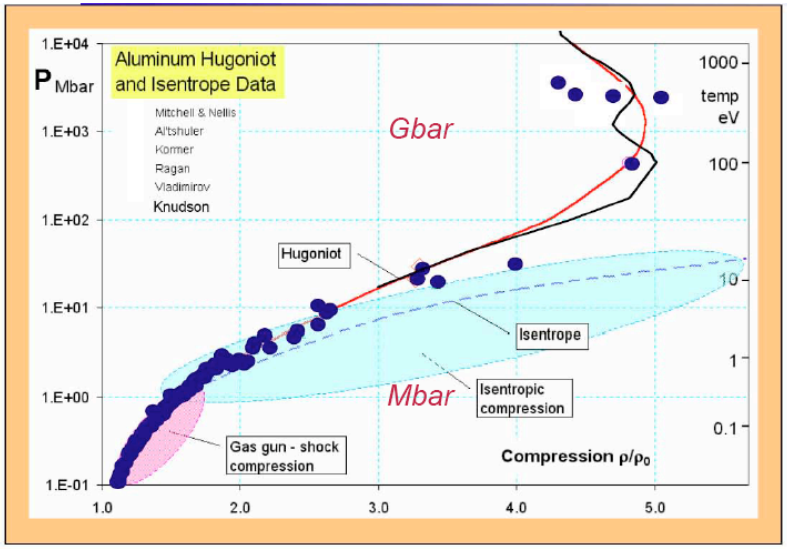


M. Purvis et al. Physical .Review E. 76, 046402, (2007)

Warm Dense Matter Example - Generate extremely high energy density states through applying ~100 GB pressure pulses using HED facilities.

Can we make discover a route to achieving 10 fold improvements (or more) in the ability of materials to withstand extreme pressures by studying their properties at 10-100 times their normal failure point?



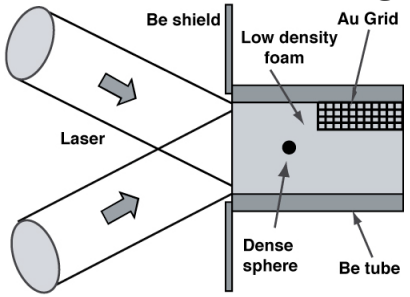


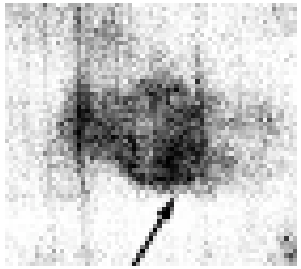
Graphics From Raymond Jeanloz

Laser experiments drive shocks; pulsed-power machines can follow isentropes.

Interpenetration is a key issue in systems created by high-Mach-number shocks

Hansen Omega experiment



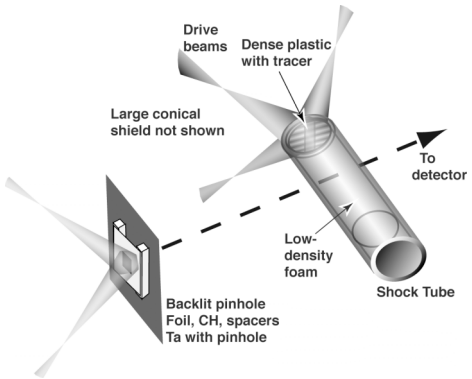


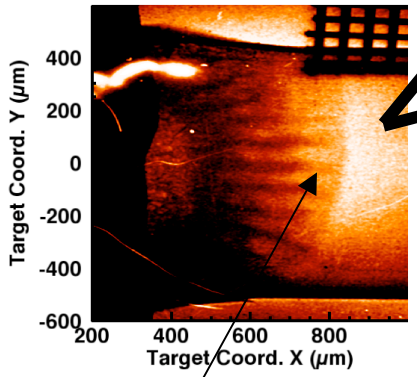
Intermediate scale:
Experiments to establish mechanisms

NIF scale:
Stripping by radiating shock

Faster than laminar stripping !

Kuranz Omega experiment

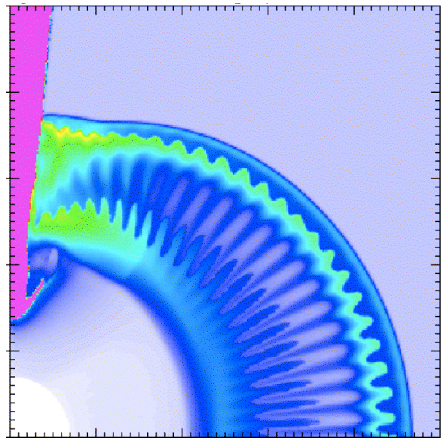




Far beyond expectation !

Omega scale:
Experiments to establish mechanisms

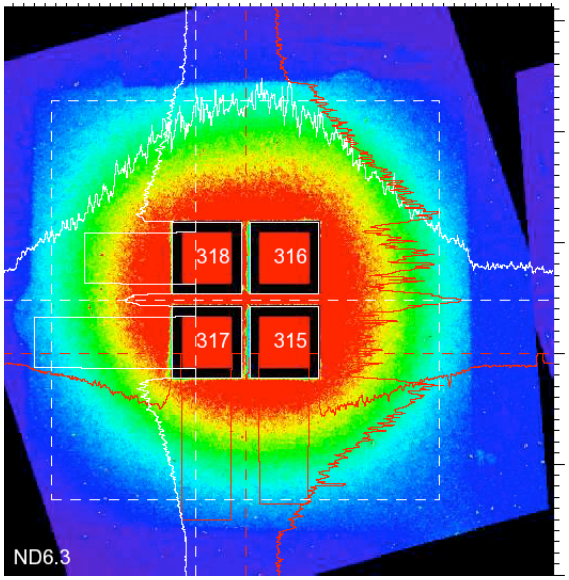
NIF scale:
Penetration in diverging multi-interface case



Michigan design calculation for NIF experiment

Towards Controlling Nonlinear Optical Processes in Photonics Devices and Laser-Plasma Interactions

Polymath Research Inc.

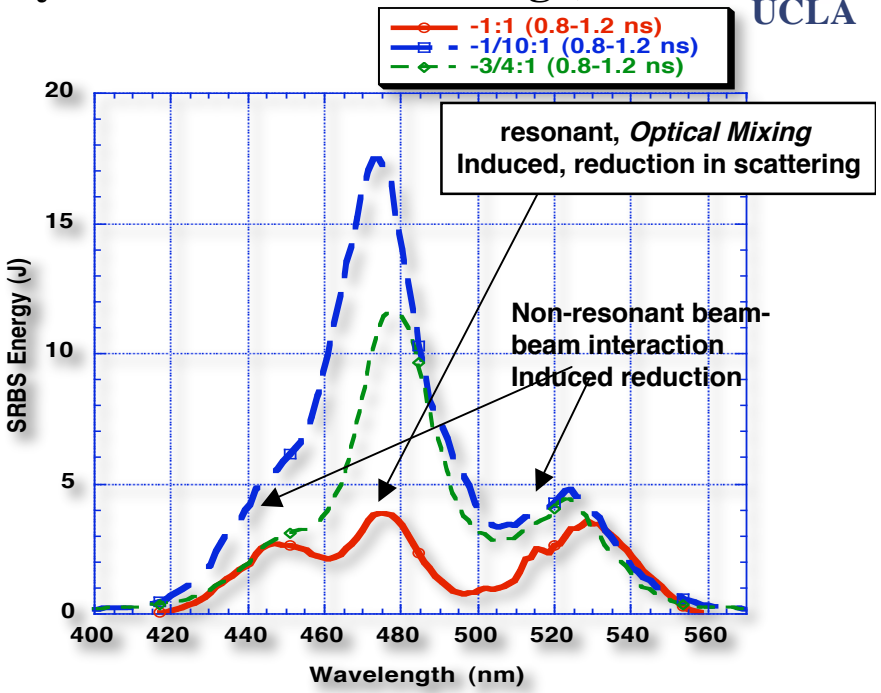


Control of Plasma Scattering by Multi-Beam Optical Mixing Effects (already demonstrated on Omega)

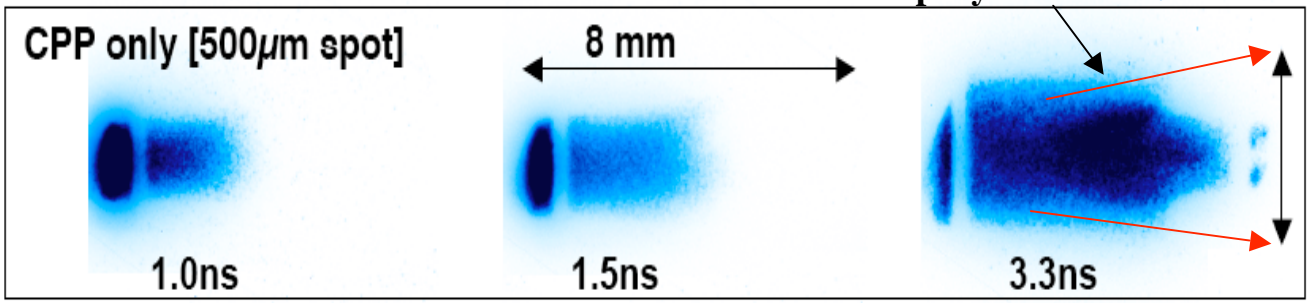
UCLA

Blue shows pump SRS spectra with 1/10:1 probe

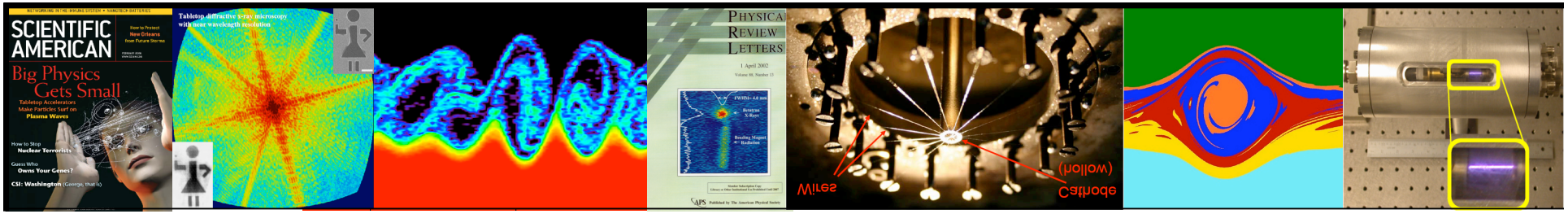
Red shows pump SRS spectra with 1:1 probe



NIF Single Beam Plasma Spray Measurements

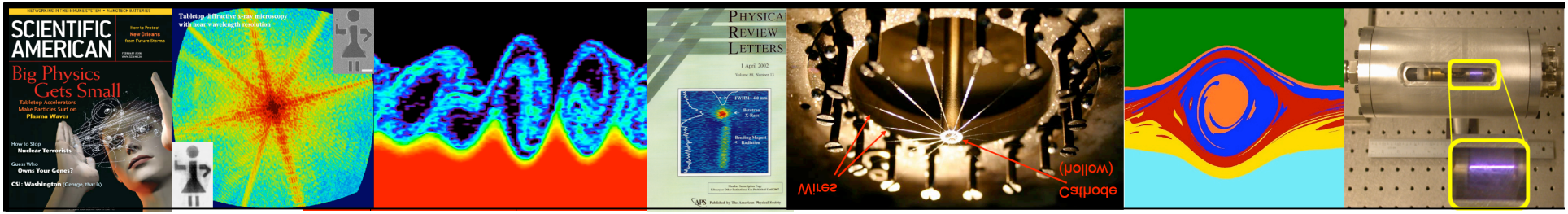


NRL



HEDSA Priorities for a Thriving Future for HEDLP

- Stewardship is challenging. Very disparate fields come together to form the essence of HEDLP.
- Transformative years are ahead. HEDLP will look very different 5 years from now.
- Peer reviewed, workshop-based priorities, inclusive transparent processes, taking full advantage of user facilities, multiscale yet well integrated efforts in science are needed.
- Consortia might have to be formed around grand challenge themes and nurtured to utilize all scale machines from small to NIF and Z and Omega EP in order to bring in students, teach them and graduate them in a pipeline of diverse approaches that mitigate risk and thus promotes success. (Virtual National Labs)
- One size does not fit all. Computational capabilities and platforms are a must for effective progress.



Realization of Our Near Term Goals for a Healthy, Thriving HEDLP Joint Program Requires a Growth Plan